Chemical Tests

Many types of chemical tests can be performed to assess varying aspects of stream water quality. However, volunteer monitoring programs are faced with both financial and technical limitations. Given these constraints, Hoosier Riverwatch trains volunteers to conduct eight of the chemical tests considered by the National Sanitation Foundation to be most useful in determining stream water quality (as well as a few additional tests):

Dissolved Oxygen
pH
Biochemical Oxygen Demand
Phosphate (Ortho- and Total)
***E.* coli and Coliform Bacteria**
Water Temperature Change
Nitrate and Nitrite
Transparency/Turbidity

Riverwatch Chemical Testing Instructions

Hoosier Riverwatch does not require volunteers to use a standard set of equipment or methods for chemical testing. However, the majority of volunteer groups actively participating in the program have received equipment through the Riverwatch Equipment Application program. The chemical testing instructions provided are for the most common methods used by volunteer stream monitoring groups in Indiana. They are also the methods presented during Hoosier Riverwatch training sessions.

Prior to 2004, the methods utilized by the Riverwatch program were different than those presented in this manual. Supplemental instructions for the use of these previously-provided kits (the HACH Stream Survey kit and the GREEN Standard Water Monitoring Kit) are provided on the web at www.Riverwatch.in.gov - click on Equipment.

Hints For Performing Chemical Tests

✓ Do not store chemical testing kits in your car, in direct sunlight, or in any extreme temperatures. The chemical reagents will degrade.

✓ **Practice**! The more familiar you are with the tests, the easier they will be to perform, and the more accurate your results will be.

✓ Perform each test multiple times or have another volunteer read the results to assure precision.

✓ Wear protective gloves and safety goggles. Do not wear sunglasses when reading the test results.

✓ Rinse collection tubes or bottles with *sample* water before collecting the sample.

✓ Rinse testing tubes and bottles with *distilled* water after completing each test.

✓ Wash your hands when you are finished.

✓ Obtain your water sample from the stream's main stream flow (usually in the middle). Take the sample 3-5 inches under the surface. See Figure 11 and more tips on the next page!

How to Discard Chemical Waste

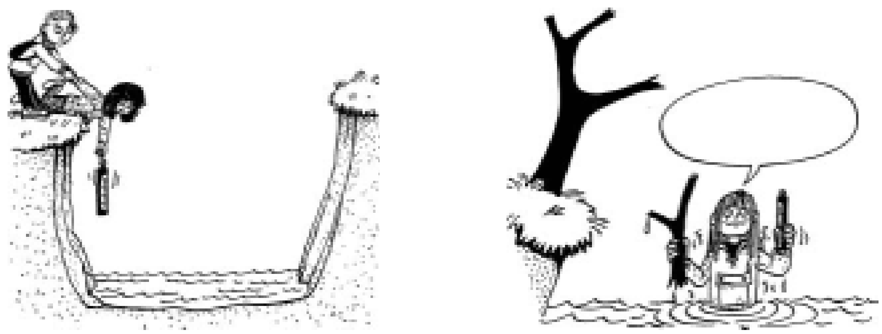
Label a plastic container with a secure lid (such as a margarine or milk container) with “Chemical Waste." Place liquids and solids in the plastic container along with cat litter. The chemical waste is in a solid form and can be discarded with your regular trash.

Tips on Collecting Water Samples

How you physically obtain the water sample depends on the size, depth, and banks of your stream. Most Hoosier Riverwatch volunteers sample wadeable streams. If you are wading, make sure that you collect water from a point upstream of where you are standing, being careful not to stir up any sediment. The sample must be collected in a clean container to avoid contamination. Collecting water directly from the stream with the container used for the chemical test is preferred. Lower your container down 3 to 5 inches below the surface of the water (or until your wrist is completely submerged) so that your sample is representative of the whole stream. Be sure **to rinse your collection container three times with sample water** before collecting your final sample.

Deep water or steep banks are dangerous (see Figure 11 below). Depending upon conditions at your site, you may need to use alternative sampling techniques. If you have a bridge at the site, you may be able to lower a sampling container or bucket down to the stream. When sampling with a bucket and line, it is helpful to have a small (~ 6 oz.) weight fastened to the rim of the bucket to tip it over. At some sites, you may be able to sample with an extension rod or cup on a stick (see Appendix A-7) from the edge of the stream. Regardless of the method of collection, sample water should be collected from the **main stream flow**.

Figure 11



Pictures from GLOBE 1997.

Units of Concentration (ppm vs mg/L)

What does part per million (ppm) mean? How much are we talking about? The following examples are listed on the "Water on the Web" (http://wow.nrri.umn.edu/wow/under/units.html) to provide further understanding of these units of concentration. One part-per-million is equal to:

- one car in bumper-to-bumper traffic from Cleveland to San Francisco
- one inch in 16 miles
- one minute in two years
- one ounce in 32 tons
- one cent in $10,000

So, how can it be that one part per million (ppm) of something in water (e.g. dissolved oxygen) is the same as one milligram per liter (mg/L)? It's because a liter of water weighs 1000 grams and a milligram is 1 one thousandth of a gram.

This is true for freshwater since the density of freshwater is 1 g/mL (1 g/mL = 10^{-3} g/10^{3} mL = 10^{-6}, or 1 ppm), but it does not hold for salt water because density increases with salinity.

The units **mg/L** and **ppm** are equal in fresh water.
They are used interchangeably throughout this chapter!

Chemical Monitoring Critical Thinking Questions

For Use During Hoosier Riverwatch Basic Training Workshops

Dissolved Oxygen (DO)

1. What is dissolved oxygen?
2. How does it get into the water?
3. Why is it important?
4. What other chemical parameter directly influences the amount of oxygen the water can hold?

E. coli

1. What is *E. coli*?
2. How does it get into the water? What are some sources?
3. Why do we test for it?
4. What other chemical parameters are high *E. coli* levels often associated with?

pH

1. What is pH?
2. What is pH influenced by? What can happen in the environment to change the pH of water?
3. What can pH affect?
4. What other chemical parameters affect pH?

Biochemical Oxygen Demand 5-Day (BOD5)

1. What is BOD5? What does it measure?
2. What types of things, when "broken down," contribute to high BOD5 levels?
3. What problems can result from high BOD5 levels?
4. What other chemical parameters are generally associated with high BOD5 levels?

Water Temperature Change

1. What does testing for water temperature change involve?
2. What can cause water temperature to change (in particular, what can cause it to increase)?
3. What problems result from increases in water temperatures?
4. What other chemical parameter may lead to increased water temperature?

Phosphate

1. What are phosphates?
2. How do they get into the water? What are the sources?
3. What can result from excess phosphates in water?
4. What other chemical parameters are affected by high phosphate levels?

Nitrates

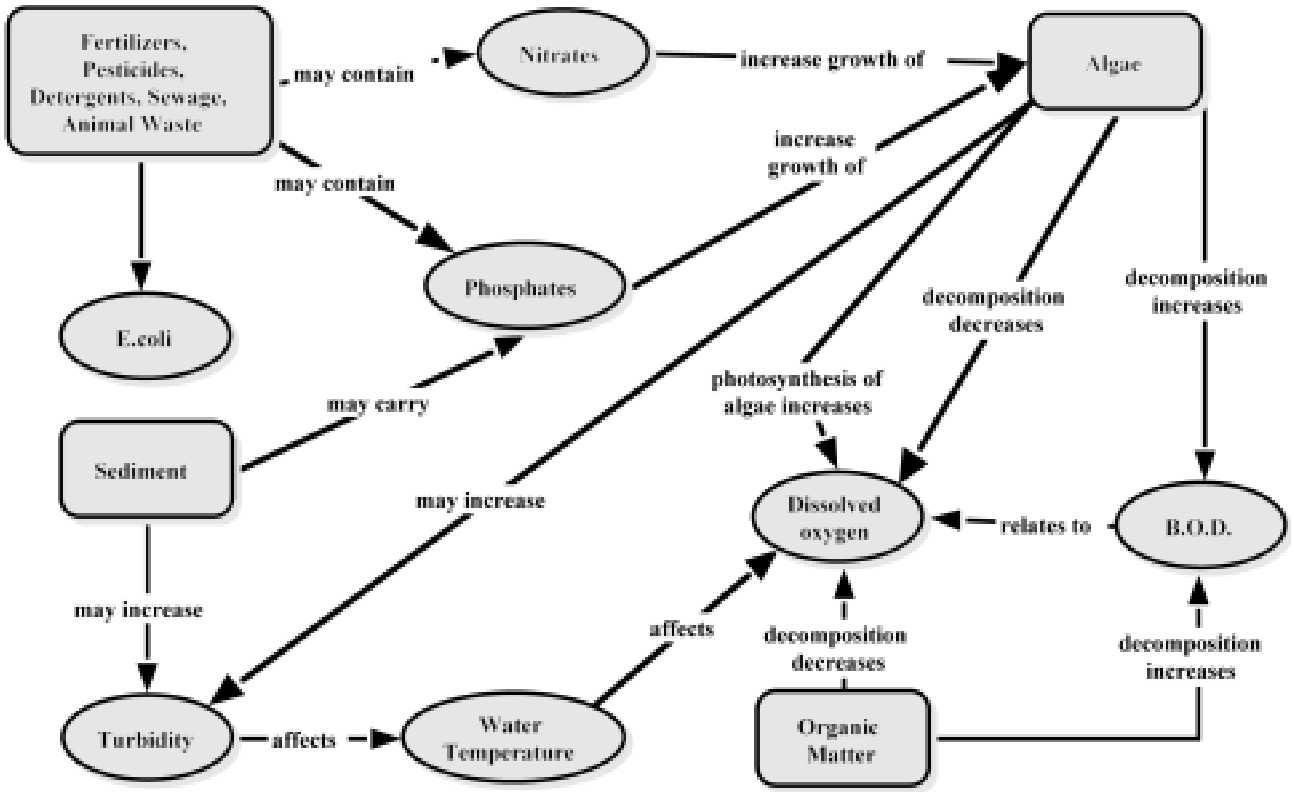
1. What are nitrates?
2. How do they get into the water? What are the sources?
3. What can result from excess nitrates in water?
4. What other chemical parameters are affected by high nitrate levels?

Turbidity

1. What is turbidity?
2. What causes water to be turbid? What are the sources?
3. What problems can result from excessive turbidity?
4. What other chemical parameters may also be associated with highly turbid water?

Water Monitoring Parameters are Interrelated

Aquatic chemistry is complex and is influenced by many interrelated factors. The simplified concept map below may help in understanding these relationships in an aquatic environment. The rectangles represent watershed inputs into a river or stream, while the circles represent chemical parameters we measure to determine water quality.



Units of Measurement and Indices

(Information modified from *Rivers Curriculum Guide: Biology*)

An index is a rating system that assigns a value to an object or process, or to specific qualities it may possess. Grades are indices of academic achievement; other index examples include movie guides, TV ratings, wind chill factors, and pollen counts.

Units for Riverwatch Chemical Tests	
Dissolved Oxygen	mg/L & % Sat
E.coli & Coliform bacteria	colonies/100 mL
pH	units
BOD 5-day	mg/L
Temperature Change	°C
Phosphate	mg/L
Nitrate/Nitrite	mg/L
Transparency/Turbidity	cm/in or NTU

An index easily allows you to observe and quantify fluctuations in river or stream water quality. Using an index ratio over a period of time can indicate whether the water is becoming more polluted or cleaner. The indices used in studying a river or stream offer a mathematical picture that reduces many values having different units to one or two overall numbers.

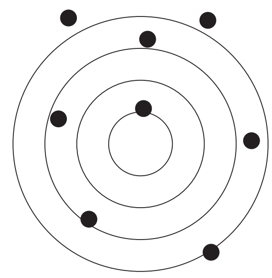
Chemical Monitoring Water Quality Index: To compare apples and oranges, you must find a unit that is common for both (e.g., apples and oranges are both fruits). The same is true for comparison of water quality parameters. Water quality experts have developed a unit common to all eight water quality tests performed by Hoosier Riverwatchers – it is called a Q-value. Determining overall water quality or comparing the results of different types of tests requires converting results from each of the eight tests to the common Q-value. Each test for water quality has its own Q-value chart and table that facilitates this conversion. Each Q-value chart follows the instructions for each test and is also listed in Appendix D. Refer to page 56 for information about Q-values.

Precision & Accuracy

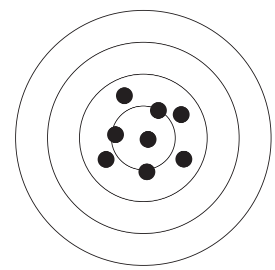
(Information modified from the *Healthy Water, Healthy People Educator's Guide* "Hitting the Mark", and the IOWATER 2003 Status Report)

The accuracy and precision of data is critical to whether it can be used for a specific purpose or not. We feel comfortable relying on data from a watch that is working correctly and has been set to the actual time to give us the correct time. However, if a watch is set one hour faster than the actual time we know that it is inaccurate, but it is still precise because it moves at a consistent rate around the dial. Of course, the most valuable watch is one that gives the correct time all the time, or consistently yields data that is both accurate and precise.

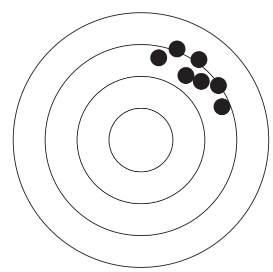
Bull's Eye Represents the "Actual" Value



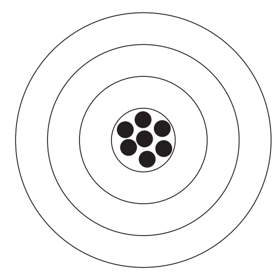
1. Neither Precise nor Accurate



2. Accurate, but not Precise



3. Precise, but not Accurate

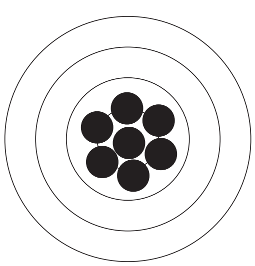


4. Both Accurate and Precise

<u>**Precision**</u> is how consistent measurements are with each other rather than with the actual value. For example, if you were trying to hit the bull's eye of a dartboard, precision is demonstrated when the darts are clustered together, but not near the bull's eye (#3). In water testing, an example of precision is when three pH tests yield the same result, even if that result is not close to the actual pH of the water. Performing multiple or replicate samples help to determine the precision of sampling.

<u>**Accuracy**</u> is a measure of how close results are to the actual value. Again, using the bull's eye, accurate darts would all be fairly close to – but not necessarily in a tight cluster in – the center of the bull's eye (#2). In water quality testing, accurate results could mean that three pH tests all measured very closely to the actual pH of the water. Standards or reference samples can be analyzed to assess accuracy of sampling.

<u>**Comparability**</u> refers to how well data can be compared with other data from the same project or data from another project. When testing water quality, comparability is maximized when standardized or accepted protocols are used for sampling, analyzing, and reporting data.



5. Same as #4, but the test is less sensitve - increments in the unit of measurement are larger

The reliability of water quality data depends on its accuracy and precision. Both tend to increase when more sophisticated technologies are used. Even though Riverwatch uses less sophisticated technologies, and limitations to the data exist, it is still valuable and can be used to identify trends, "hot" spots, areas in need of further monitoring, and, if enough data is available, can be used for watershed assessments. This is possible because Riverwatch data are comparable to professional data. Although not exact, the data provide a "ball park" figure.

Data collected following Riverwatch methods may be considered accurate, but not as precise (#5) as methods utilizing higher technology. For example, using the pH test strip, a volunteer can consistently find the result to be 8.5 (showing precision); however, if the actual value was 8.65, she would not be able to obtain this result (with accuracy) because the pH test strip has the limitation of a 1/2 unit on the pH scale.

Chemical Testing Instructions

Background information and instructions were copied or modified with permission from CHEMetrics, Inc., Water Works, Inc., Earth Force-GREEN, and the Student Watershed Research Project/Saturday Academy of Oregon.

Typical Ranges

After each set of test instructions, you will find values representing the likely ranges into which your chemical test results may fall. These ranges were created by determining the level at two standard deviations around average concentrations from the US Geological Survey fixed stations throughout Indiana from the period 1991-2002. Each range statistically represents values found on roughly two-thirds of Indiana streams and rivers tested. One-third of Indiana streams would be expected to have values higher or lower than this range. In addition, the Indiana water quality standards for rivers are included for each applicable parameter.

Times and Locations for Completing Tests

The table below provides estimated times for performing each of the tests and whether they must be completed on-site or off-site. If samples are taken off-site, they must be kept on ice or refrigerated until testing is completed (except BOD and turbidity). All tests should be completed the same day and as soon as feasible to obtain the best possible results.

Chemical Test	Time to Complete	Location
Dissolved Oxygen	5 minutes	On-site
***E*. coli and General Coliforms**	24-48 hrs to incubate / 10-15 min to count	On-site/Off-site
pH	2 minutes	On-site
Biochemical Oxygen Demand (BOD)	5 days to incubate / 5 minutes	Off-site
Water Temperature Change (1 mile)	< 5 min at each site	On-site
Orthophosphate	5 minutes	On-site/Off-site
Nitrate/Nitrite	2 minutes	On-site/Off-site
Transparency/Turbidity	5 minutes	On-site/Off-site

Other Results

Other water chemistry test results sometimes obtained by volunteers include ammonia, total solids, chlorine, chloride, conductivity, alkalinity, hardness, heavy metals, or pesticides. Any water quality results you obtain (either by your own testing or from a laboratory) may be recorded on the data sheet. Up to four additional test results may be recorded on the Chemical Monitoring Work Sheet (page 58) and in the Online Volunteer Stream Monitoring Database (page 107).

Some chemical tests require extremely sensitive and expensive equipment, and are not usually performed by volunteer monitors. A few examples of these tests include: mercury, PCBs, some pesticides, DNA source-tracking of bacteria, and pharmaceuticals.

Dissolved Oxygen

Oxygen is as important to life in water as it is to life on land. Most aquatic plants and animals require oxygen for survival. Although oxygen atoms are present in the water molecule (H_2O), most aquatic life require oxygen in the free elemental state (O_2) as a dissolved gas. The amount of oxygen in water is called the dissolved oxygen (DO) concentration. Oxygen dissolves into the water from the atmosphere until the water is saturated. Aquatic plants, algae, and plankton also produce oxygen as a by-product of photosynthesis. Which is why oxygen levels rise during the day and fall at night during respiration.

DO is an important measure of stream health. Presence of oxygen in water is a positive sign, while absence of oxygen from water often indicates water pollution. Aquatic organisms require different levels of DO. Dissolved oxygen levels below 3ppm are stressful to most aquatic life. DO levels below 2 or 1ppm will not support fish. Levels of 5 to 6ppm are usually required for healthy growth and activity of aquatic life.

Some of the factors affecting DO are:

- Temperature (water can't hold as much dissolved oxygen at higher temperatures)
- Altitude/atmospheric pressure
- Turbulence
- Plant growth/photosynthesis
- Amount of decaying organic material

% Saturation

Two pieces of information are needed to interpret dissolved oxygen levels – the DO concentration (in ppm or mg/L) and the water temperature. From these two values, the percent saturation can be determined. Percent saturation is the level of DO in the water compared to the total amount of DO that the water has the ability to hold at a given temperature and pressure. The table on page 39 shows the mg/L of DO that represents 100% saturation at each given temperature.
Cold water can hold more dissolved oxygen than warm water. For example, water at 26°C is 100% saturated with 8 ppm dissolved oxygen. However, water at 8 °C can hold up to 12 ppm DO before it is 100% saturated. Thus, daily and seasonal temperature changes, as well as thermal pollution, greatly impact oxygen levels and aquatic life in streams and rivers.

Supersaturation

High levels of bacteria or large amounts of rotting organic material can consume oxygen very rapidly and cause the percent saturation to decrease. Conversely, water may become **supersaturated** for short periods of time, holding more than 100% of the oxygen it would hold under normal conditions. Supersaturation is often caused by high levels of photosynthesis in streams over-loaded with aquatic plants and algae. Supersaturation may also occur at the base of dams due to increased pressure. Supersaturation can be harmful to aquatic organisms, causing gas bubble disease, a condition similar to “the bends”, which scuba divers may get if they surface too fast.

Problem

Lack of sufficient dissolved oxygen required by most aquatic organisms to breathe. Lack of oxygen increases the toxicity of other chemicals (e.g. hydrogen sulfide and ammonia).

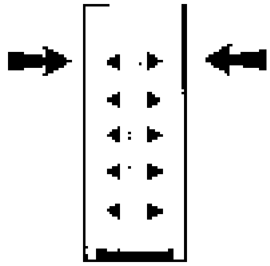
Causes

- Rapid decomposition of organic materials, including dead algae, shoreline vegetation, manure or wastewater decreases oxygen.
- High ammonia concentrations in the stream use up oxygen in the process of oxidizing ammonia (NH_4^+) to nitrate (NO_3^-) through nitrification.
- Less oxygen can dissolve in water at higher temperatures.
- Lack of turbulence or mixing to expose water to atmospheric oxygen results in low dissolved oxygen concentrations.

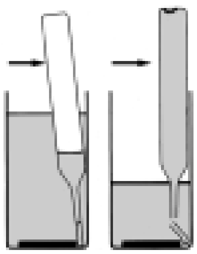
Dissolved Oxygen Instructions

These instructions are for use with the CHEMetrics Dissolved Oxygen Test Kit K-7512.

1. Triple rinse sample cup with water to be tested. Fill the sample cup to the 25mL mark.



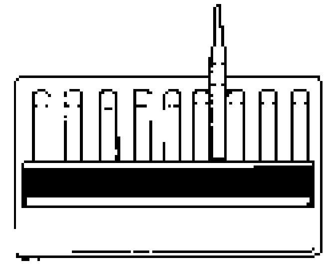
2. Place the CHEMet ampoule in the sample cup. Snap the tip by pressing the ampoule against the corner of the cup. The ampoule will fill, leaving a small bubble to facilitate mixing.



3. Mix the contents of the ampoule by inverting it five times, allowing the bubble to travel from end to end each time. Wipe all liquid from the exterior of the ampoule. Wait **2 minutes** for color development.

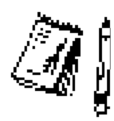
2:00 min

4. Hold the comparator in a nearly horizontal position while standing directly beneath a bright source of light. You may remove the color comparator from the lid. Place the ampoule between the color standards until the best color match is found. If the ampoule is between two color standards, you can estimate half-way between the concentrations.



5. Use the graph in Figure 12 (on the next page), to calculate percent saturation. By running a straight edge from the appropriate water temp. reading to DO (mg/L), you will be able to determine percent saturation along the angled (middle) scale. If you took the temperature in Fahrenheit, use a conversion formula $C = (F - 32.0)/1.80$, or look at the conversion diagram on page 48.

6. Record the dissolved oxygen concentration to the nearest mg/L <u>and</u> the percent saturation.



Example:
DO = 8 mg/L Temp = 16 °C
Look on chart = 80% Saturation

Important Note:
The CHEMet ampoules and color standards contain a reagent which deteriorates upon prolonged exposure to light. They will remain stable only if stored in the dark. The reagent should be a light straw color with no hint of blue or green when the ampoule is removed from the box. The normal shelf life of the color standards is two years.

Typical range for DO = 5.4 to 14.2 mg/L

Indiana Average = 9.8 mg/L

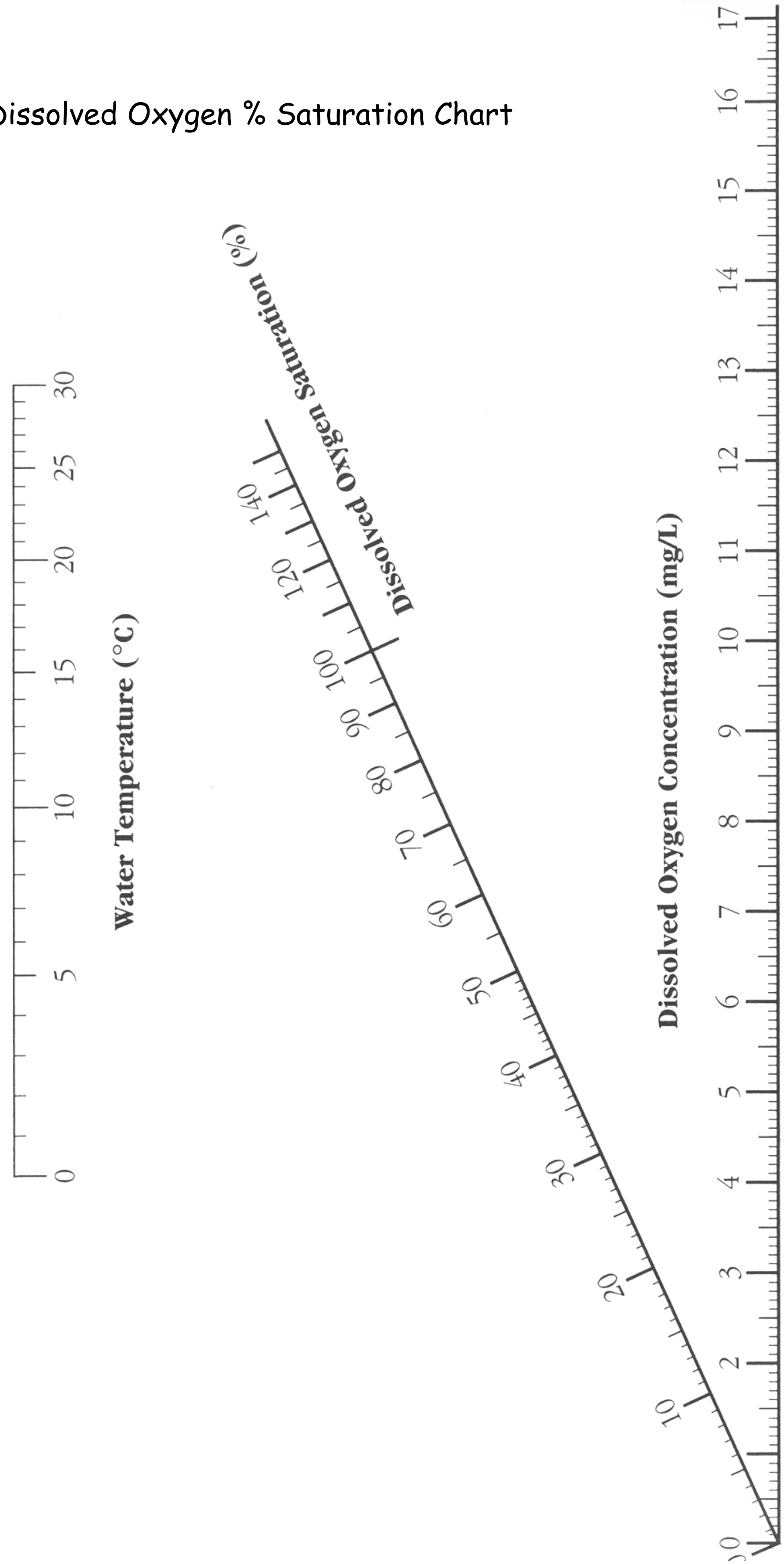
State Water Quality Standard: Avg > 5mg/L, not < 4mg/L

Percent Saturation is the % of mg of oxygen gas dissolved in one liter of water at a given temperature **compared with the maximum** mg of oxygen gas that can remain dissolved in one liter of water at the same temperature and pressure.

The table on page 39 tells you how much dissolved oxygen (mg/L) your water sample would need to be 100% saturated at a given temperature.

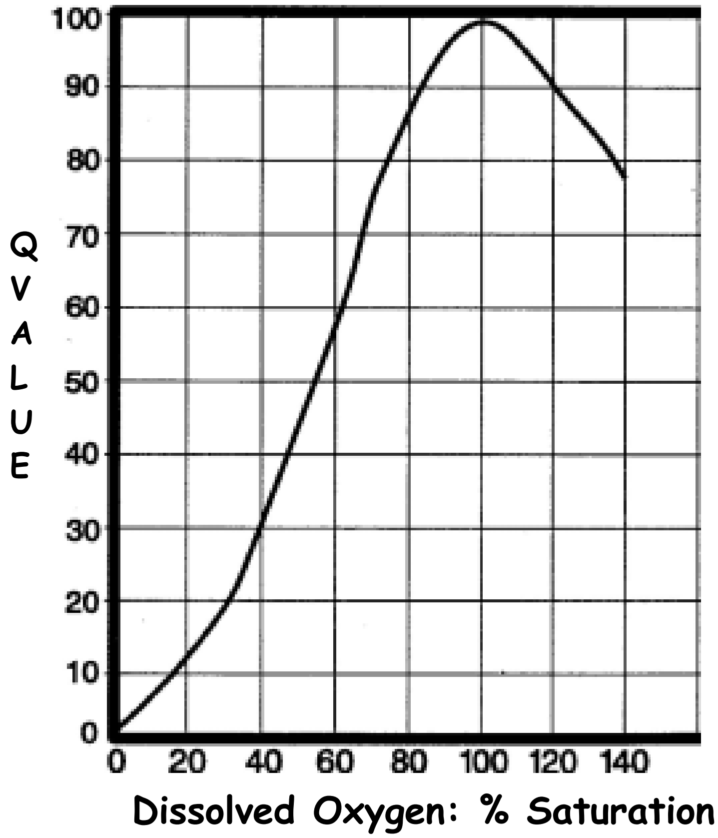
For example: If your stream temperature is 22 °C, then it would be 100% saturated with dissolved oxygen at 8.90 mg/L.

Figure 12: Dissolved Oxygen % Saturation Chart



Dissolved Oxygen Q-Values

(For more information about Q-values, see page 56.)



DO (% Saturation)	Q-Value
0	0
10	8
20	13
30	20
40	30
50	43
60	56
70	77
80	88
85	92
90	95
95	97.5
100	99
105	98
110	95
120	90
130	85
140	78
>140	50

Amount of Dissolved Oxygen (mg/L) your water sample would need to be 100% Saturated at the given temperature.*

Temp °C	Dissolved Oxygen (mg/L)	Temp °C	Dissolved Oxygen (mg/L)	Temp °C	Dissolved Oxygen (mg/L)
1	14.60	16	10.07	31	7.41
2	14.19	17	9.85	32	7.28
3	13.81	18	9.65	33	7.16
4	13.44	19	9.45	34	7.05
5	13.09	20	9.26	35	6.93
6	12.75	21	9.07	36	6.82
7	12.43	22	8.90	37	6.71
8	12.12	23	8.72	38	6.61
9	11.83	24	8.56	39	6.51
10	11.55	25	8.24	40	6.41
11	11.27	26	8.09	41	6.31
12	11.01	27	7.95	42	6.22
13	10.76	28	7.81	43	6.13
14	10.52	29	7.67	44	6.04
15	10.29	30	7.54	45	5.95

*at sea level

E. coli Bacteria

Fecal coliform bacteria are found in the feces of warm-blooded animals, including humans, livestock, and waterfowl. These bacteria are naturally present in the digestive tracts of animals, but are rare or absent in unpolluted waters. Fecal coliform bacteria typically enter water via combined sewer overflows (CSOs), poor septic systems, and runoff from agricultural feedlots. The bacteria can enter the body through the mouth, nose, eyes, ears, or cuts in the skin.

E. coli is a specific species of fecal coliform bacteria used in Indiana's state water quality standards. Forty-one percent (8,660 miles) of Indiana streams do not support primary contact recreation due to high *E.* coli bacteria levels. *(Source: IDEM Integrated Water Quality Monitoring and Assessment Report, 2002)*

Bacteria & Human Health

Some strains of *E.* coli can lead to illness in humans. While not all strains of *E.* coli are pathogenic themselves, they occur with other intestinal tract pathogens that may be dangerous to human health. We test for the presence of *E.* coli as an indicator of fecal contamination.

The US EPA has determined that *E.* coli bacteria counts above 235 colonies per 100 mL indicate that more than 8 people out of 1,000 who come into contact with the water may become sick. But it is important to remember that as *E.* coli counts go up, it is the <u>chance</u> that someone will get sick that goes up - there are many other things that determine if a person will become sick:

- how long someone is in contact with the water
- if water comes into contact with a person's eyes or mouth
- if the person has skin abrasions or wounds
- the age and health of the person, as that can determine a person's susceptibility to illness.

(Source: USGS Chattahoochee BacteriALERT - http://ga2.er.usgs.gov:80/bacteria/helpwithtables.cfm)

Hoosier Riverwatch is participating in a six-state research project from 2004-2006 in conjunction with Purdue Cooperative Extension to determine the most accurate and usable method for detecting *E.* coli and coliform bacteria by volunteers.

Problem

High levels of E. coli indicate fecal contamination and the potential presence of pathogens that could cause human illness.

Causes

- Human waste from poorly functioning septic systems, wastewater treatment systems, or combined sewer overflows.
- Pet waste, wildlife (including waterfowl).
- Livestock or manure runoff from fields.

E. Coli Testing Instructions

The following instructions are adapted from those provided by Micrology Laboratories, Inc. for use with the Coliscan Easygel method. For details on use and interpretation of results, please refer to the manufacturer's instructions. Be sure to request a copy of the color ID photo examples when ordering! Contact them at 1-888-EASYGEL or www.micrologylabs.com. You can also download a bacteria monitoring supplement from the www.Riverwatch.in.gov.

CHECKLIST

- ❒ *Pre-treated* petri dish from Micrology Labs
- ❒ Sterile pipettes, Whirl-pac bag or other sterile collection container
- ❒ Bottle(s) of Coliscan Easygel (thawed)
- ❒ Permanent marker (e.g. Sharpie)
- ❒ Tape, Rubber Gloves, Ice and cooler
- ❒ Bleach and water-tight bag for disposal

Do not rinse these materials before or after use! They are specially pre-treated or sterilized for use. Be sure to follow the instructions provided!

Easygel *E.* Coli Instructions

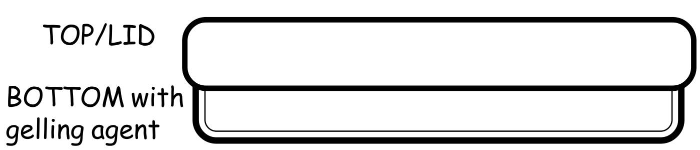
1. **Preparation** - Before you begin, remove Coliscan Easygel bottle(s) from freezer and allow to defrost. Also, label the bottom of a Micrology Labs petri dish with a permanent marker, including the date, time, location, and volume (mL) of sample water.

   (For easier identification, the amount of sample used will vary according to the suspected conditions of the water you are testing. If you suspect a high bacteria count after a recent rainfall event, transfer only 0.25-0.5 mL of sample. Typically, 3-5 mL is appropriate. Your goal is to have < 200 colonies in the petri dish.)

2. **Collection** -Wearing gloves and using only sterile collection equipment, obtain a sample for testing in one of two ways.
   a) Take a measured sample directly from the source using a sterile pipette and immediately place it into the bottle of Coliscan Easygel, or
   b) collect your sample in a sterile container (e.g. Whirl-pak Bag) and transport the water to an appropriate test site. Obtain sample slightly below the water's surface.

   (You must decide if plating will take place onsite or offsite. If offsite, water samples and Easygel bottles containing samples kept longer than 10 minutes prior to plating should be kept on ice in a cooler or in a refrigerator until plating.)

3. **Plating** - Transfer a measured volume of sample water into the bottle of Coliscan Easygel. Gently swirl and invert the bottle to distribute the Easygel and then pour the mixture into the bottom half of a Micrology Labs pre-treated petri dish. *(If you hold the petri dish up to a light, you can see the gelling agent.)* Being careful not to splash over the side or onto the lid, gently swirl the dish until the mixture is evenly distributed across the bottom.



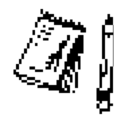
   While its contents are still in liquid form, place the dish right-side-up directly onto a level location out of direct sunlight. Solidification will occur in approximately 45 minutes.

4. **Incubation** - Turn the petri dish upside down (to reduce condensation) and incubate at 35° C (95° F) for 24-48 hours or at room temperature for approximately 48 hours.

5. **Counting/Analysis** - After the appropriate incubation period, inspect the dish. Count all of the purple/blue-violet colonies in the dish and record the results in terms of *E.* coli per 100 mL of water. You may also count all of the pink and magenta colonies and record these as coliforms. Do not count pin-point colonies < 1mm in size, and disregard any light blue, teal, or white colonies, as these indicate other types of bacteria.

   To report the total number of *E.* coli and coliform bacteria colony forming units (CFU) per 100ml, first divide 100 by the number of mL you used in your sample, then multiply that figure by the # of colonies you counted in your petri dish.

Example: You used 3 mL of stream water & you counted 4 purple colonies in your dish.



First divide 100 by 3 = 33.3
Then multiply 33.3 x 4 =

133.2 colonies/100 mL

6. **Disposal** - To prepare your sample bottle and petri dish for disposal in normal trash, place 5 mL (about 1 teaspoon) of bleach onto the surface of the plate. Allow to sit for at least 5 minutes. Place in a watertight plastic bag and discard in trash.

* **Expiration - Coliscan Easygel bottles (not petri dishes) need to be stored in a freezer. Coliscan Easygel medium is good for 1 year.**

Typical range for *E.* coli =
133 to 1,157 colonies/100 mL

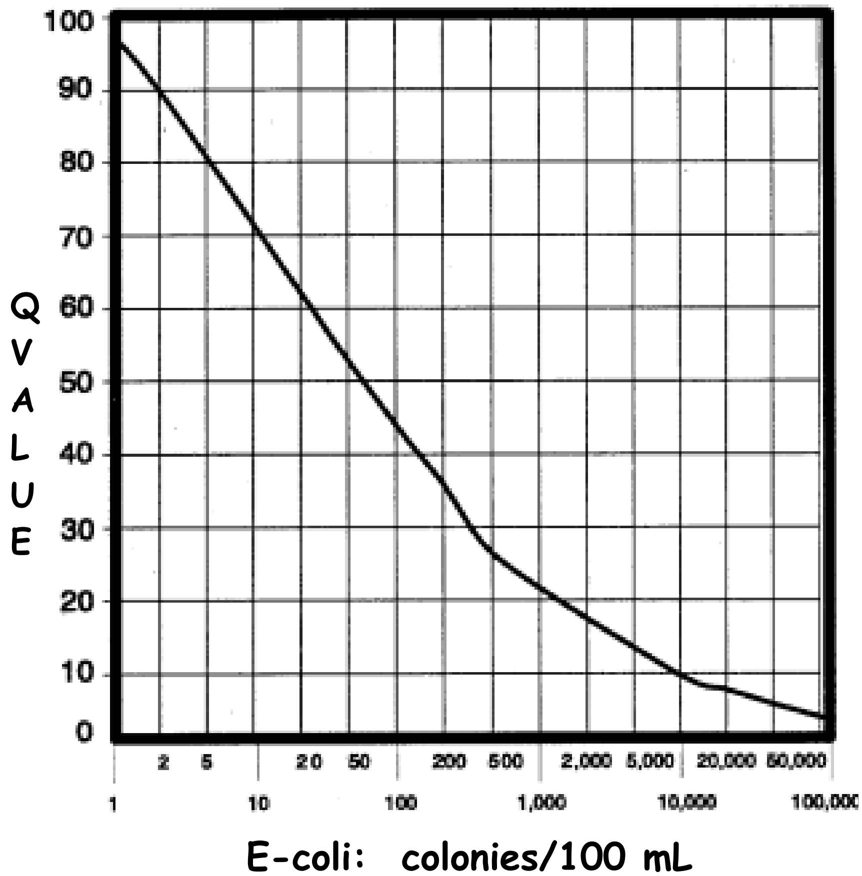
Indiana Average =
645 colonies/100mL

State Water Quality Standard for total body contact recreation:

<235 CFU/100 mL (single sample),
AND
< 125 CFU/100 mL (Geometric mean of 5 samples equally spaced over 30 days)

E. coli Q-Values

(For more information about Q-values, see page 56.)



E.Coli (colonies/100mL)	Q-Value
0-1	98
2	89
5	80
10	71
20	63
50	53
100	45
200	37
500	27
1,000	22
2,000	18
5,000	13
10,000	10
20,000	8
50,000	5
100,000	3
>100,000	2

pH

The pH test is one of the most common analyses in water testing. Water (H_2O) contains both hydrogen ions (H^+) and hydroxide ions (OH^-). The relative concentrations of these ions determine whether a solution is acidic or basic.

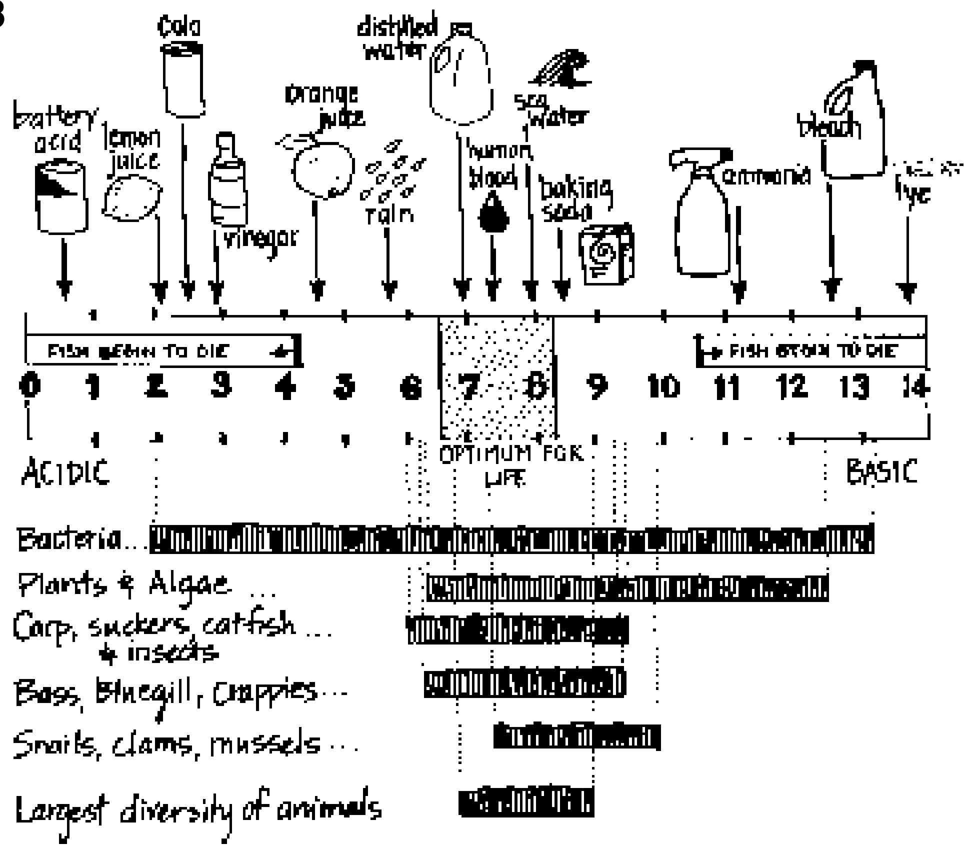
The activity of the hydrogen ions is expressed in pH units (pH = power of Hydrogen). The concentration of H^+ ions is used to estimate pH. The pH scale ranges from 0 (most acidic) to 14 (most basic), with 7 being neutral. If the solution has more H^+ ions than OH^- ions, it is acidic and has a pH less than 7. If the solution contains more OH^- ions than H^+ ions, it is basic with a pH greater than 7. It is important to remember that pH is measured on a logarithmic scale; it is reported as the negative log of the hydrogen ion concentration ($-\log [H^+]$). A change of 1 pH unit means a ten-fold change in the ion concentration. For this reason, pH units are not normally averaged; however, to simplify calculations, Riverwatch allows volunteers to average pH.
The pH level is an important measure of water quality because aquatic organisms are sensitive to pH, especially during reproduction. Adult organisms may survive, but young will not be produced. A pH range of 6.5 to 8.2 is optimal for most organisms (see Figure 13 and page 101).

Many natural processes affect pH. Waterbodies with higher temperatures have slightly lower pH values. Also, algae blooms remove carbon dioxide (CO_2) from the water during photosynthesis, which may raise pH to 9 or more.

Runoff from abandoned mine lands can produce acid main drainage which lowers pH. Lower pH values increase the solubility of some heavy metals, such as copper and aluminum, allowing them to dissolve into the water and become toxic to aquatic organisms.

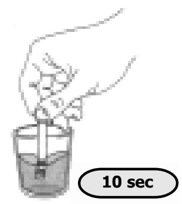
Most natural waters have pH values of 5.0 - 8.5. Freshly fallen rainwater has a pH of 5.5 - 6.0 due to the presence of CO_2 in the atmosphere, but air pollution due to automobiles and coal-burning power plants creates acid rain which is even more acidic. Alkaline soils and minerals (limestone) buffer the effects of acid rain and may raise pH to 8.0 - 8.5.

Figure 13



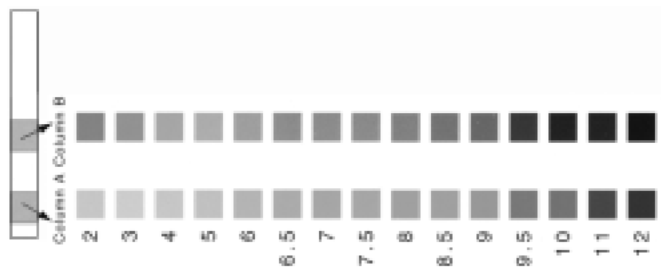
pH Instructions – For use with WaterWorks™ pH Test Strips (#481104).

1. Triple rinse sample collection container with water to be tested, then collect a sample.
2. Dip one test strip into sample for <u>10 seconds</u> with a constant, gentle back-and-forth motion.



3. Remove the strip and <u>shake once</u>, briskly, to remove excess sample.
4. <u>Wait 20 seconds</u> and match with the closest color on the chart for <u>both</u> Columns A and B.

5. For best performance, complete the reading <u>within 10 seconds</u>.
6. Record the pH level.



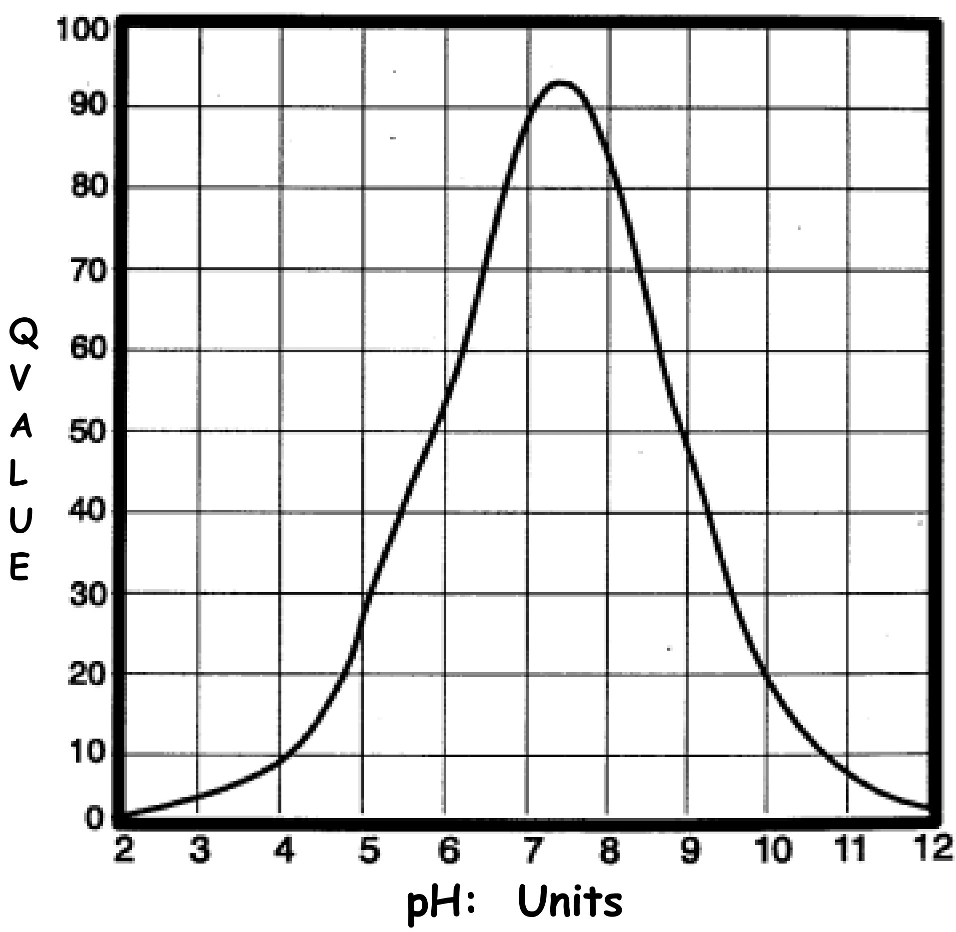
Typical range for pH = 7.2 to 8.8
Indiana Average = 8.0

State Standard = between 6 - 9

Due to the state's limestone geology, Indiana surface waters will typically have a pH that is relatively basic (> 7).

pH Q-Values

(For more information about Q-values, see page 56.)



pH (units)	Q-Value
<2	0
2	2
3	4
4	8
5	24
6	55
7	90
7.2	92
7.5	93 (max)
7.7	90
8	82
8.5	67
9	47
10	19
11	7
12	2
>12	0

Biochemical Oxygen Demand

Biochemical oxygen demand (BOD_5) is a measure of the amount of oxygen used by aerobic (oxygen-consuming) bacteria as they break down organic wastes over five days. Polluted streams, or streams with a lot of plant growth (and decay), generally have high BOD_5 levels. High levels indicate that large amounts of organic matter are present in the stream. Streams that are relatively clean and free from excessive plant growth typically have low BOD_5 levels.

In slow moving and polluted waters, much of the available dissolved oxygen (DO) is consumed by bacteria, which rob other aquatic organisms of the oxygen needed to live. Streams with higher DO levels, such as fast-moving, turbulent, cold-water streams, can process a greater quantity of organic material. Therefore, interpretation of BOD_5 levels depends upon the conditions of the stream sampled, as some streams can "handle" more waste than others. However, in general, a healthy stream has high DO levels and low BOD_5 levels – be careful not to confuse the two!

The following is a rough guide to what various BOD_5 levels indicate:

1-2 mg/L BOD_5	Clean water with little organic waste
3-5 mg/L BOD_5	Fairly clean with some organic waste
6-9 mg/L BOD_5	Lots of organic material and bacteria
10+ mg/L BOD_5	Very poor water quality. Very large amounts of organic material in water.

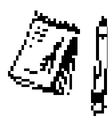
Instructions - In addition to a black (light-free) bottle, use the CHEMetrics Dissolved Oxygen Test Kit K-7512.

1. Rinse, then lower a stoppered black (light-free) bottle below the water's surface. Allow water to flow into the bottle for approximately 2 minutes. Ensuring that no air bubbles exist, replace the stopper or lid while the bottle is underwater. Remove bottle from the water.

2. Place the BOD sample in a light-free location (e.g., desk drawer or cabinet) at room temperature and allow it to sit undisturbed at approximately 20 ^{o}C (68 ^{o}F) for 5 days.

3. After 5 days, remove the BOD bottle and perform Steps 1 through 4 of the DO test (page 37) using the BOD sample water.

4. Determine the BOD_5 level by subtracting the mg/L of the BOD sample from that of the original DO sample taken 5 days prior.



Example: 11 mg/L (original DO - day 1)
- 6 mg/L (DO 5 days later)
5 mg/L (BOD_5)

Typical range for BOD_5 =
0 to 6.3 mg/L
Indiana Average = 1.5 mg/L

Note: If dissolved oxygen is not detected after the 5-day period, the BOD of the sample cannot be determined. In this case, report BOD as > DO_{day1} and note that no dissolved oxygen was detectable after 5 days.

Problem

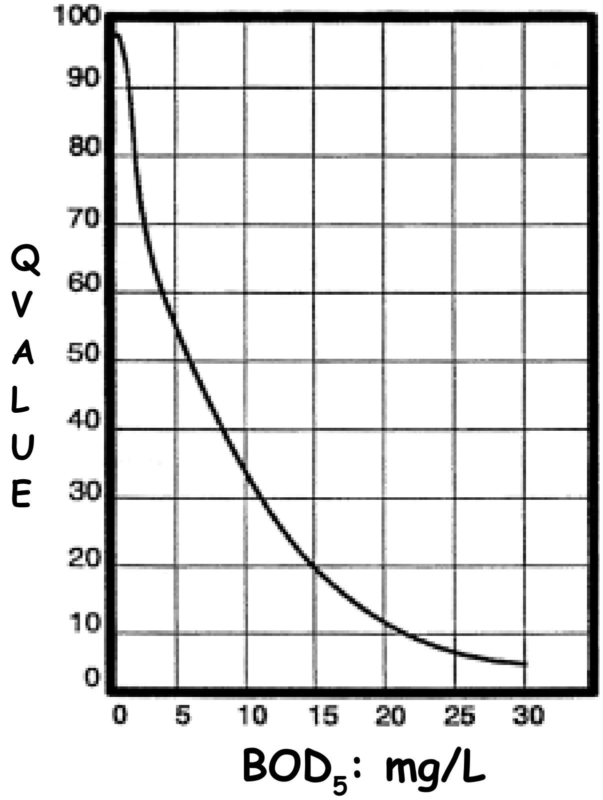
High levels of organic matter - including leaves, dead fish, garbage, some industrial waste, fertilizer, pet waste, and sewage from poor functioning septic systems or combined sewer overflows - and some ions (ammonia in particular) can lead to rapid exhaustion of dissolved oxygen.

Causes

- Municipal wastewater and septic tank effluent that has not been completely treated will use up oxygen.
- Eutrophication and hot weather can cause algae blooms. When bacteria decompose dead algae, oxygen is consumed which increases BOD.

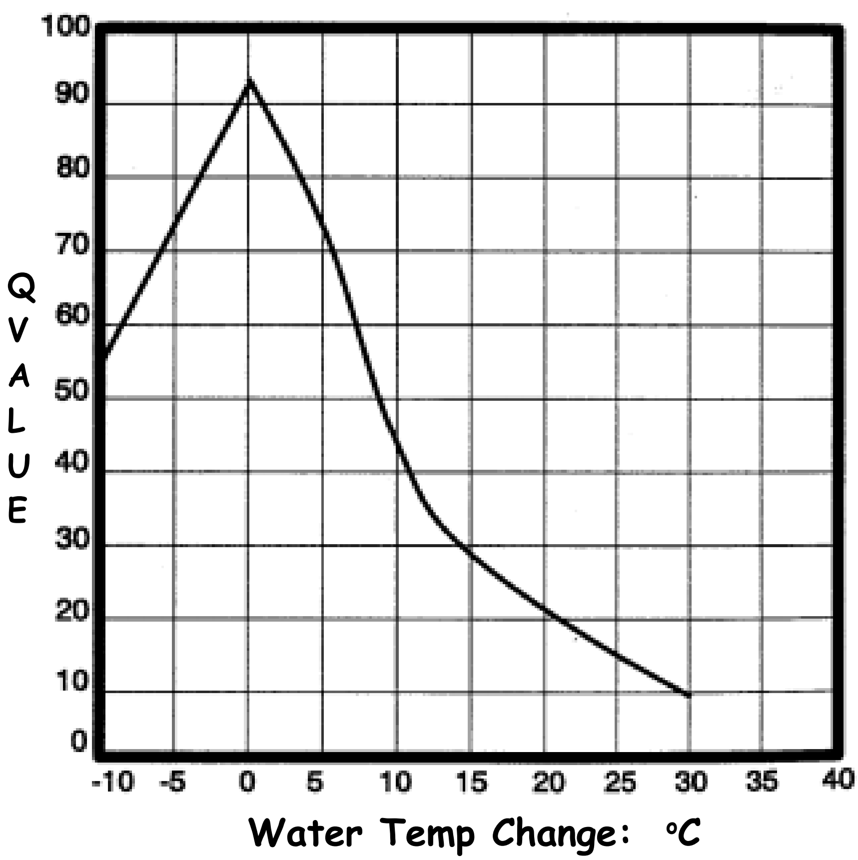
BOD5 Q-Values

(For more information about Q-values, see page 56.)



BOD 5 (mg/L DO)	Q-Value
0	96
1	92
2	80
2.5	73
3	66
4	58
5	55
7.5	44
8	40
10	33
12.5	26
15	20
17.5	16
20	14
22.5	10
25	8
27.5	6
30	5
>30	2

Temperature Change Q-Values



Change in Temp. (°C)	Q-Value
-10	56
-7.5	63
-5	73
-2.5	85
-1	90
0	93 (max)
1	89
2.5	85
5	72
7.5	57
10	44
12.5	36
15	28
17.5	23
20	21
22.5	18
25	15
27.5	12
30	10

Water Temperature Change (1 mile)

Water temperature is very important to overall water and stream quality. Temperature affects:

1. **Dissolved Oxygen Levels** – Colder water can hold more dissolved oxygen than warmer water, thus colder water generally has higher macroinvertebrate diversity. Warmer water has less dissolved oxygen. Lower oxygen levels weaken fish and aquatic insects, making them more susceptible to illness and disease (See Figure 14).

2. **Rate of Photosynthesis** – Photosynthesis by algae and aquatic plants increases with increased temperature. Increased plant/algal growth leads to increased death and decomposition, resulting in increased oxygen consumption (BOD_5) by bacteria.

3. **Metabolic Rates of Aquatic Organisms** – Many animals require specific temperatures to survive. Water temperature controls their metabolic rates, and most organisms operate efficiently within a limited temperature range. Aquatic organisms die when temperatures are too high or too low.

Water temperature varies naturally with changes of the seasons, the amount of rainfall, and flow rates. Thermal pollution (temperature increases) can threaten the balance of aquatic ecosystems. To determine if your river or stream is thermally polluted you must take a temperature reading at two different locations. Increased water temperature may be caused by many sources, some of which are listed below. If water temperature decreases within a mile of the sampling site, there may be a source of cold water, such as a spring, entering the stream.

Problem

Aquatic organisms have narrow optimal temperature ranges. In addition warmer water holds less dissolved oxygen.

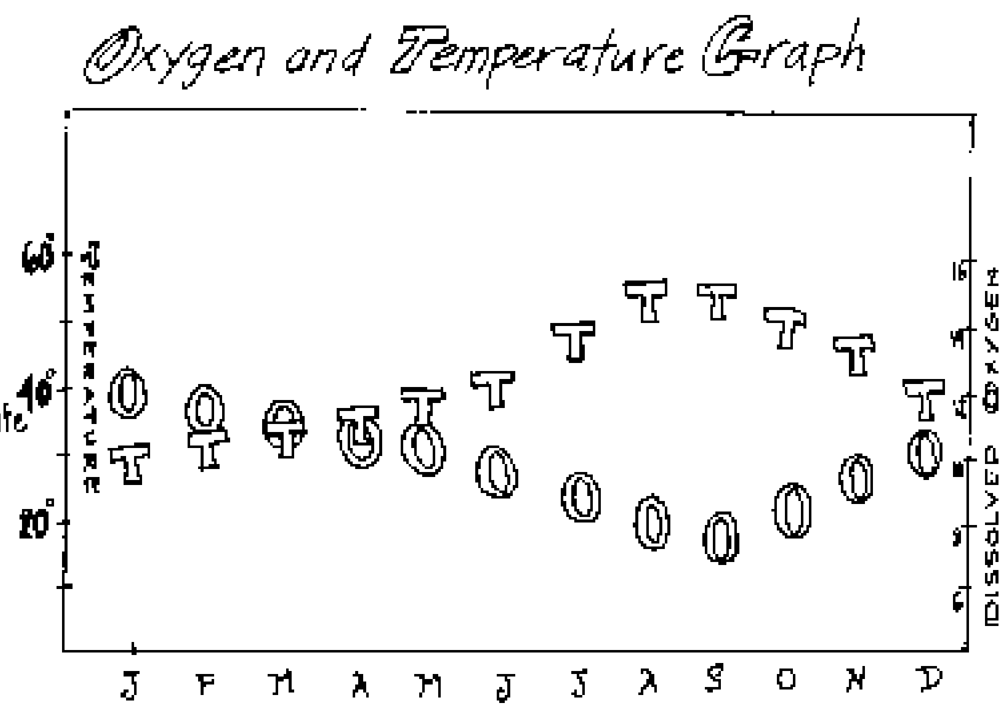
Causes

- Loss of shading by trees in the riparian zone and the watershed.
- Runoff from roads and parking lots
- Discharges from municipal wastewater and industrial sources.

Figure 14

When you learn what organisms are sensitive to low O_2 levels...

..you can predict when macroinvertebrate diversity will be lowest ↓ and highest ↑.



The **air temperature** needs to be taken while the thermometer is completely dry, so do that first! Hang the thermometer somewhere where it's not leaning against a solid object and where it's protected from direct wind and sunlight. The thermometer will take **5 - 10 minutes** to equilibrate. **Record the result**!

Temperature Change Instructions

1. Place the thermometer below the water's surface (e.g., the same depth at which other tests are performed). If possible, obtain the temperature reading in the main streamflow.

2. Swirling gently, hold the thermometer in the water for approximately 2 minutes or until the reading stabilizes.

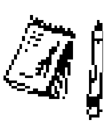
3. Record your reading in Celsius. *(Note: If you are using a thermometer that reads only in Fahrenheit, look at Figure 15 or use the following equation to convert to Celsius:*

$$C = (F - 32.0)/1.8$$

4. Choose a portion of the stream with roughly the same degree of shade and velocity as in Step 1, and conduct the same test approximately 1 mile upstream as soon as possible using the same thermometer.

5. Calculate the difference between the downstream and upstream results. Record the temperature change in Celsius and note if the change is positive or negative.

Example:

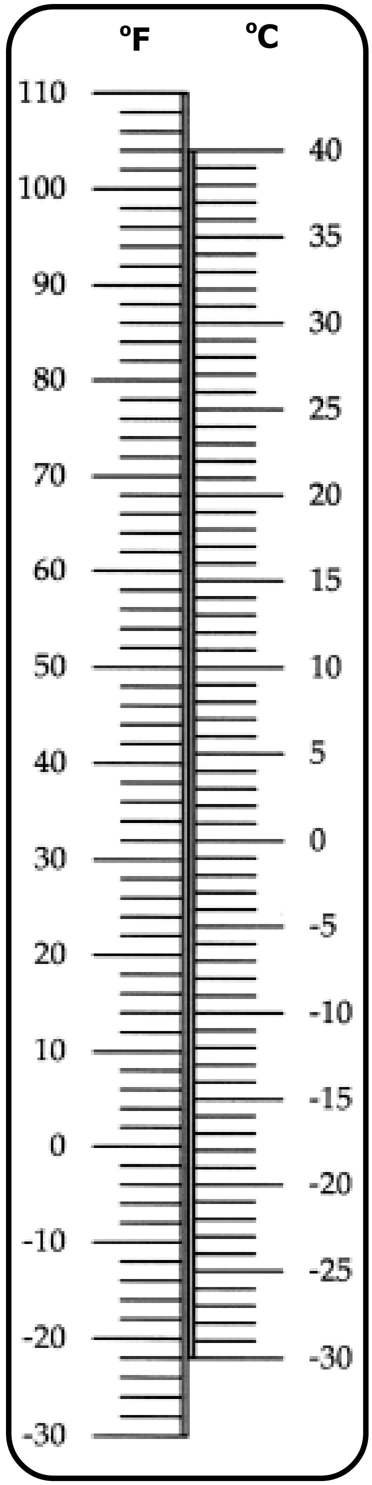


Downstream Temp (Your Site)
\- Upstream 1-mile Temp
= Temperature Change (+/-)

State Water Quality Standard:

< 5° F change downstream (approximately 2.8° C)

< 2° F change for trout streams (approximately 1.1° C)



* freezing point of fresh water

Figure 15

Temperature conversion image and air temp instructions provided by Friends of Casco Bay, ME.

Orthophosphate and Total Phosphate (PO_4)

Phosphorus (P) is essential to plant and animal life, and its presence in the environment is natural. Problems with phosphorus as a water pollutant result not from its presence, but from the addition of excessive amounts. Aquatic ecosystems develop with very low levels of phosphorus. The addition of seemingly small amounts of phosphorus can lead to problematic algal blooms when added to aquatic systems.

Phosphorus enters surface waters in organic matter (dead plants and animals, animal waste), attached or adsorbed to soil particles, or in a number of man-made products (detergents, fertilizers, industry wastes). Phosphorus is an important nutrient in fertilizer because it increases terrestrial plant growth (vegetation). When transported into aquatic systems, phosphorus increases aquatic plant growth (e.g. algae, weeds), as well. When phosphorus levels are too high, excess plant and algal growth creates water quality problems. Plants begin to die and decompose, depleting the dissolved oxygen supply in the water - a condition called **hypoxia**, which can lead to fish kills in some cases. Phosphorus is also released from the sediments and decomposing plants back into the water, continuing the cycle. The reaction of the aquatic system to an overloading of nutrients is known as **eutrophication**. (See Figure 16 on the next page). Hypoxia and eutrophication, to some extent, occur within many of our lakes and streams every year, and occur on a larger scale at the mouth of the Mississippi River where there's a large "dead zone" in the Gulf of Mexico.

Orthophosphate

Phosphorus (P) occurs in nature in the form of phosphates (PO_4). Phosphate levels higher than 0.03ppm contribute to increased plant and algae growth. Orthophosphates are one form of phosphates. Orthophosphates are dissolved in the water (mostly inorganic) and are readily available for plant uptake. Thus, the orthophosphate concentration is useful as an indicator of *current* potential for algae blooms and eutrophication.

Total Phosphate

Unlike nitrogen and other nutrients, phosphorus does not have a gaseous phase. Once it is in an aquatic system, it remains there and cycles through different forms unless physically removed (e.g. by dredging). Over time some of the other forms of phosphates attached to particles in the water column and in the sediments (including organic forms) can be changed into orthophosphates, becoming available for plant growth. For this reason, it is useful to test for total phosphate levels.

However, testing for total phosphate requires the use of a strong acid and boiling your sample for thirty minutes. The chemistry methods currently utilized by Hoosier Riverwatch do not include a means for obtaining total phosphate results. If you would like to perform this test, contact Hoosier Riverwatch for information.

Problem

Most fresh water has naturally low phosphate levels, and this limits algal growth. If excessive phosphates enter surface water, it can support rapid algal growth. When the algae die, their decomposition by bacteria uses up oxygen and may produce odors and algal toxins.

Causes

- Phosphorus occurs naturally in soil. Sediments from soil erosion and runoff are often a significant source of phosphorus. These may enter the stream via bank erosion or runoff from forestry, agriculture, and urban lands. Phosphorus can desorb from soil particles and enter solution.
- Phosphorus can come from manure sources, such as treatment lagoons, over-fertilized agricultural fields, or waterfowl.
- Urban sources of phosphorus may include: storm drains, parking lot and road runoff, construction sites, inadequately treated municipal wastewater and septic tank effluent, and lawn fertilizer.

EUTROPHICATION

(NUTRIENT OVERLOAD)

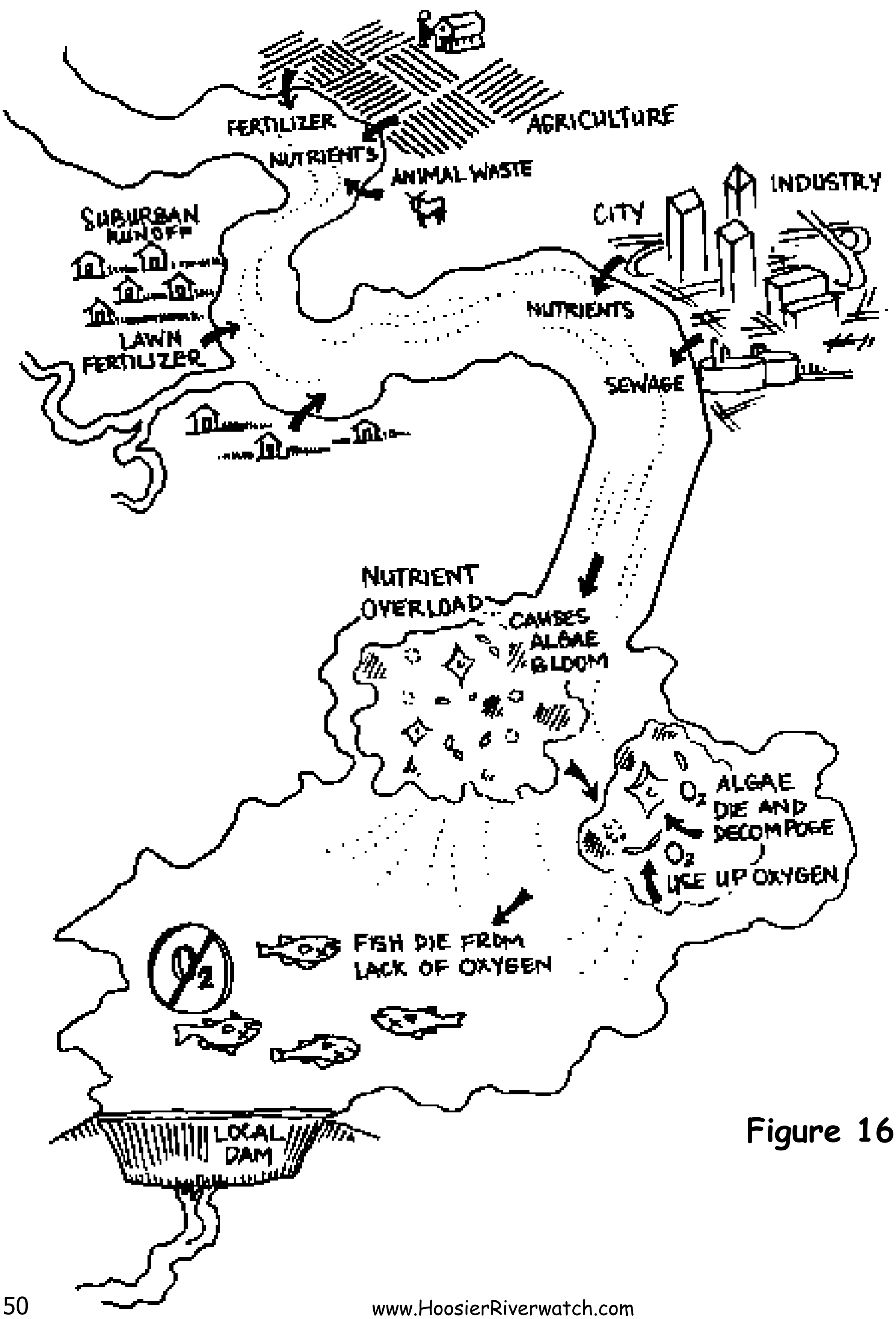
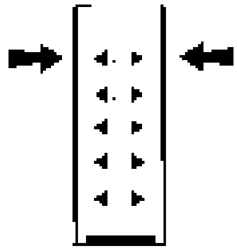


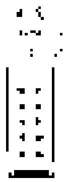
Figure 16

Orthophosphate Instructions

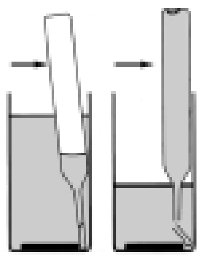
These instructions are for use with the CHEMetrics Dissolved Oxygen (DO) Test Kit K-8510.

1. Triple rinse sample cup with water to be tested. Fill the sample cup to the 25 mL mark with the sample.





2. Add 2 drops of A-8500 Activator Solution. Place black cap on sample cup and shake it to mix the contents well.

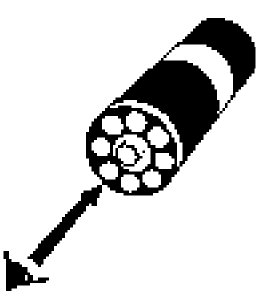


3. Place the CHEMet ampoule in the sample cup. Snap the tip by pressing the ampoule against the side of the cup. The ampoule will fill leaving a small bubble to facilitate mixing.

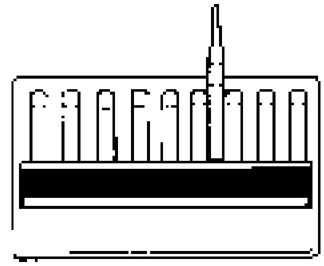
4. Mix the contents of the ampoule by inverting it ten times, allowing the bubble to travel from end to end each time. Wipe all liquid from the exterior of the ampoule. Wait **2 minutes** for full color development.

5. Use the appropriate comparator to determine the level of orthophosphate in the sample. If the color of the CHEMet ampoule is between two color standards, you can estimate half-way between the concentrations.

   a. Low-range (0-1 ppm) Place the ampoule, flat end downward into the center tube of the low range comparator. Direct the top of the comparator up toward a source of bright light while viewing from the bottom. Rotate the comparator until the color standard below the ampoule shows the closest match.



   b. High Range (0-10 ppm) Hold the high range comparator in a nearly horizontal position while standing directly beneath a bright source of light. You may remove the comparator from the lid. Place the ampoule between the color standards until the best color match is found. If the ampoule is between two color standards, you can estimate half-way between the concentrations.



6. Record the results in mg/L on the Chemical Monitoring Work Sheet. There is no Q-value for Orthophosphate, and this result may not be entered on the Water Quality Index Data Sheet.

Results of the Orthophosphate test may be entered on the Chemical Monitoring Work Sheet & submitted to the online database.

However, there is no Q-value for Orthophosphate, and the results are not part of the Water Quality Index Data Sheet.

Important Note:
The CHEMet ampoules and color standards contain a reagent which will deteriorate upon prolonged exposure to light. They will remain stable only if stored in the dark. The reagent should be completely clear when the ampoule is removed from the box.

There are no state water quality standards for Orthophosphate. However, we do know the **Total Phosphate** typical range (0 - 0.85 mg/L) and Indiana average (0.05 mg/L) values.

We generally expect orthophosphate values to be less than total phosphate, since orthophosphate is but one component of total phosphate.

Nitrate & Nitrite

Nitrogen makes up about 80% of the air we breathe, and it is found in all living things. Nitrogen occurs in water as nitrate (NO_3), nitrite (NO_2), and ammonia (NH_3). It enters the water from human and animal waste, decomposing organic matter, and runoff of fertilizer from lawns and crops.

Nitrates are an essential nutrient for plant growth. Similar to phosphates, these are a main ingredient in fertilizers and can lead to increased aquatic plant growth and eutrophication. (See page 49 for a more detailed discussion of eutrophication and nutrients.) Unpolluted waters generally have a nitrate level below 4ppm. Nitrate (NO_3) levels above 40 ppm and nitrite (NO_2) levels above 3.3 ppm are considered unsafe for drinking water.

Problem

Nitrogen works with phosphorus to increase algae growth and cause eutrophication.

Causes

- Nitrogen can come from manure, such as treatment lagoons and over fertilized fields.
- Nitrogen is the most abundant nutrient in commercial fertilizers. Runoff from agriculture, golf courses, and lawns is high in nitrogen, especially if it rains soon after fertilization.
- Sewers are the #1 source of nitrates in Indiana's surface water.

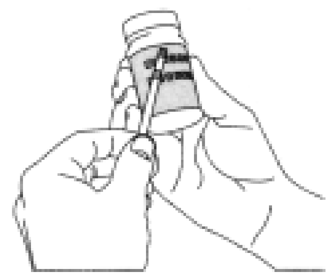
Typical range for NITRATE (NO_3) = 0 to 36.08 mg/L

Indiana Average = 12.32 mg/L

Instructions - For WaterWorks™ Nitrate/Nitrite Test Strips (#480009)

1. Triple rinse sample collection container with water to be tested. Collect sample.

2. Dip one test strip for 2 seconds without motion. Remove the strip, but **do not shake off excess sample water.**
3. Wait 1 minute for colors to develop.

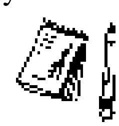


4. Match Nitrite (pad nearest handle) to the closest color. Also match Total Nitrate as N (end pad) to the closest color. Complete color matching within the next 1 minute.
5. Record results on Chemical Monitoring Work Sheet and apply conversions to Nitrate (NO_3^-) and Nitrite (NO_2^-).

Conversion Ratio:

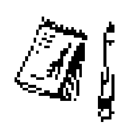
1) To convert nitrate nitrogen (as N) to nitrate (NO_3^-), multiply the test strip result by 4.4.

Example: 5 ppm (test strip) x 4.4
= 22 ppm nitrate (NO_3).



2) To convert nitrite nitrogen (as N) to nitrite (NO_2^-), multiply the test strip result by 3.3.

Example: 1.5 ppm (test strip) x 3.3
= 4.95 ppm nitrite (NO_2).



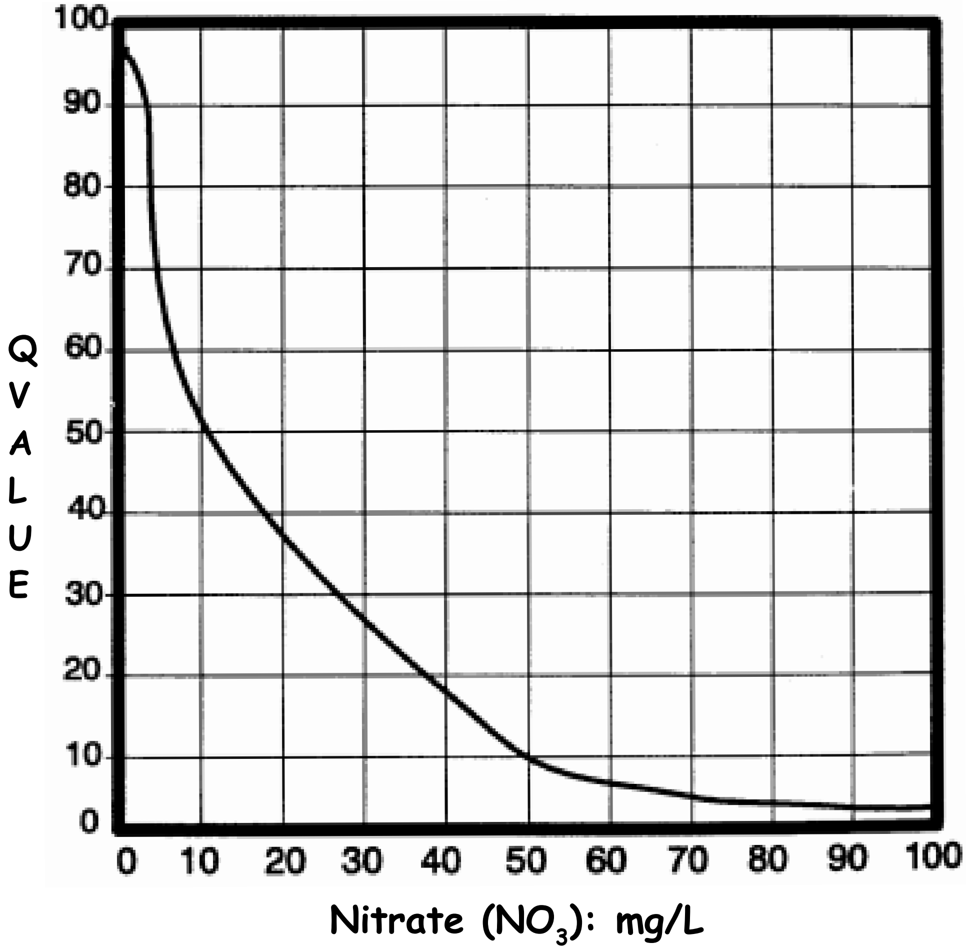
Important Note:

Store test strips in dry, cool place (< 30 °C) and away from direct sunlight.
Use by date printed on package.

Nitrate NO_3 (the value after the result is multiplied by 4.4) is used in the Q-Value chart and the Water Quality Index Data Sheet.

Nitrate (NO_3) Q-Values

(For more information about Q-values, see page 56.)



Nitrate-N (mg/L NO_3-N)	Q-Value
0	98
0.25	97
0.5	96
0.75	95
1	94
1.5	92
2	90
3	85
4	70
5	65
10	51
15	43
20	37
30	24
40	17
50	7
60	5
70	4
80	3
90	2
100	1
>100	1

There is no Q-value chart for Nitrite (NO_2).

Turbidity & Transparency

Turbidity is the relative clarity of the water and is measured by shining a light through the water column. Turbid water is more cloudy, and is caused by suspended matter including clay, silt, organic and inorganic matter, and algae. These materials scatter and absorb light, rather than allowing it to shine through the water column in a straight line. Turbidity should not be confused with color, since darkly colored water (like tea) can still be clear and not turbid.

Turbid water may be the result of soil erosion, urban runoff, algal blooms, and bottom sediment disturbances caused by boat traffic or abundant bottom feeding fish.

If a stream is very turbid, light will not reach through the water column and many reactions, especially photosynthesis, will be limited. When water is turbid, the floating particles absorb heat from the sun, raising water temperature and thus lowering dissolved oxygen levels. The particles can also kill fish and aquatic invertebrates by clogging their gills and smothering their habitat.

Transparency measures the scattering of light and is observed by the depth at which we can see an object in the water column. We measure the transparency of our water sample, and use a pre-determined relationship to convert our transparency results (cm) to units of turbidity (NTUs).

Problem

The water looks "dirty." Photosynthesis is limited because organisms in the water column receive no light. Temperature is increased due to light absorption.

Causes

- Soil erosion and runoff from agricultural fields, lawns, parking lots, construction sites, or the stream bank itself.
- Algae and organic matter also contribute to turbidity.

Transparency Instructions - Turbidity can be assessed with a very accurate but expensive electronic turbidimeter. Transparency can be assessed with many types of equipment, including a homemade Secchi disk or transparency tube. See Appendix A for information about purchasing or making your own transparency tube.

For use with a Transparency Tube:

1. Rinse sample container with sample water. Collect sample water in a bucket or other container from which you can pour the water into a calibrated transparency tube. *(Note: Avoid stirring bottom sediments when sampling at midstream.)*

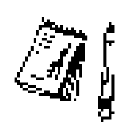
2. Avoid direct sunlight by turning your back to the sun. Swirl the water in your bucket to mix and slowly pour sample water into the tube until the symbol is not visible.

3. While looking vertically down into the tube, release water until the point at which you can barely see the "X" on the bottom of the tube, and record the result in centimeters or inches. *(Note: Do not wear sunglasses while taking this measurement.)*

4. Repeat the above steps to verify the result. *(Note: Allowing one or two people to repeat the test or view the tube may help obtain a more accurate result.)*

5. Convert the tube reading from inches or centimeters to Nephelometer Turbidity Units (NTUs) using the Q-Value chart on the next page. If the symbol is still visible when your tube in full, indicate this on your data sheet:

Example: > 60 cm;
which is equal to < 15 NTUs



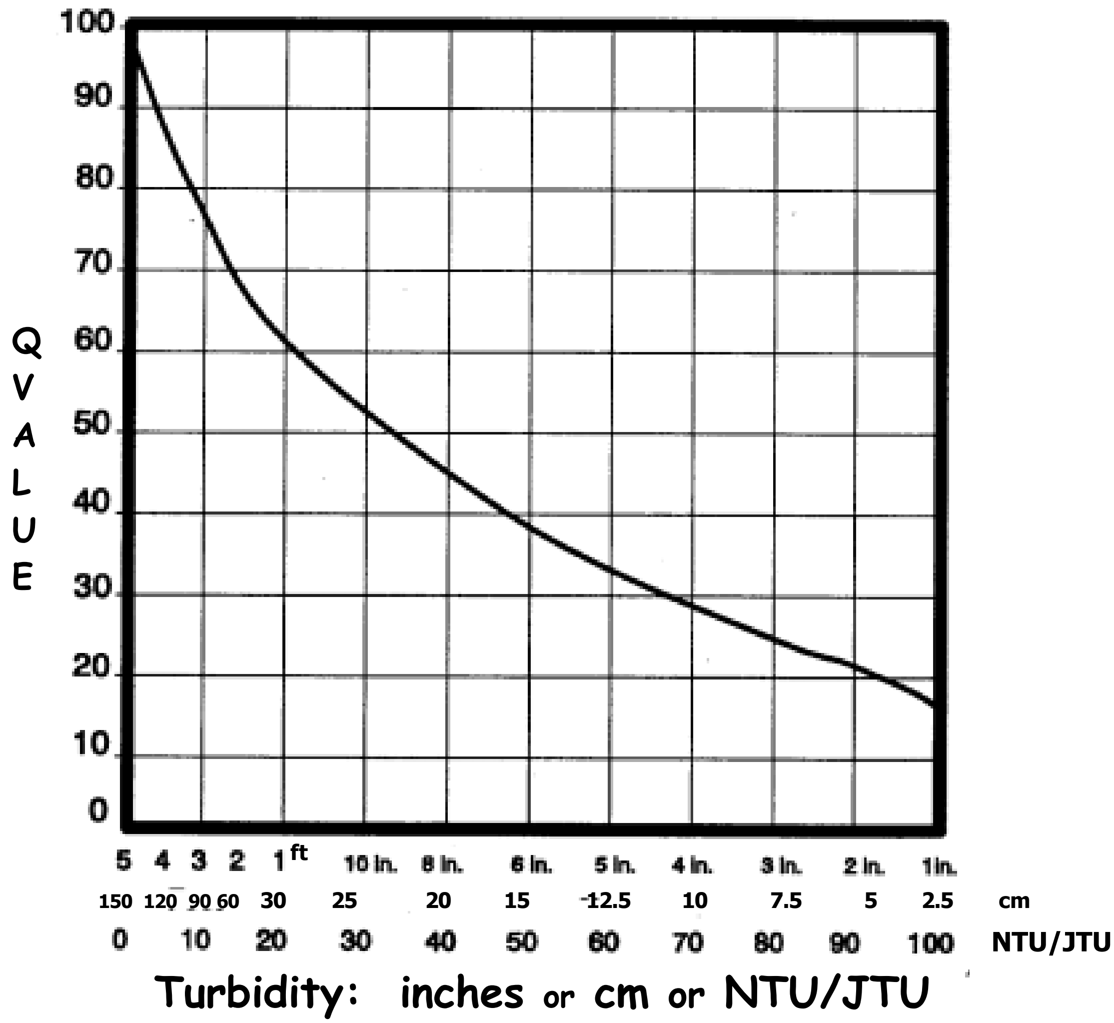
6 Properly clean your transparency tube - see Appendix page A-1.

Typical range for TURBIDITY =
0 to 173 NTU
Indiana Average = 36 NTU

Turbidity Q-Values

(For more information about Q-values, see page 56.)

Transparency (cm)	Turbidity (NTU)	Q-Value
Reading from Tube	Use in Database	
150	0	97
120	5	84
90	10	76
>60 (turb tube)	<15 (turb tube)	70
60	15	68
30	20	62
27.5	25	57
25	30	53
22.5	35	48
20	40	45
15	50	39
12.5	60	34
10	70	28
7.5	80	25
5	90	22
2.5	100	17
<2.5	>100	5



Chemical Monitoring Work Sheet & Data Sheet

Why use the chemical monitoring work sheet?

The chemical monitoring work sheet (page 58) can be taken into the field to record the results of multiple samples. Use of the work sheet is optional. Hoosier Riverwatch recommends that volunteers take multiple samples to assure higher quality stream monitoring results. Up to three replicates can be recorded on this work sheet. Obvious outliers (results that are drastically different from other values) should not be recorded or used in calculations. The average of the test results is calculated then used in the first column *(Test Results* column) on the Chemical Monitoring Data Sheet.

The data entry pages for chemical monitoring data in the Volunteer Monitoring Internet Database (See Chapter 7) are formatted like the chemical monitoring work sheet. The volunteer enters data for the number of replicate samples completed. The database computes the average values and Q-values, then displays the final results in the format of the Water Quality Index data sheet.

How the water quality index (WQI) works

The Chemical Monitoring Data Sheet on page 61 utilizes a Water Quality Index. The Water Quality Index provides a simple analysis of the results of the eight chemical tests. If you complete at least six of the eight tests, you can derive a single score that will let you know if the stream results are: Excellent, Good, Medium, Bad, or Very Bad for that particular monitoring session. You can also use this value to track changes in your site over time, or compare the quality with other stream sites.

Each of the tests is weighted according to its level of importance to the overall water quality (in this particular index). Dissolved oxygen has the highest weighting factor (0.18); therefore, the oxygen results are the most important value in determining the water quality rating using the index. The weighting scheme allows analysts to condense complex test results into a common water quality measurement that can be readily communicated to the public and to other volunteers. The Water Quality Index score is like a final grade - weighting the results of multiple tests and exams.

How to use the Q-value charts

In order to obtain a WQI Rating, you must first determine the Q-value for each test. Each test (except Orthophosphate and Nitrite) has its own Q-chart immediately following the instructions (pages 36-55). To find the Q-value: locate your test result on the bottom of the appropriate chart (x-axis). Draw a vertical line up from your test result until it intersects the curved line (Q-line). From this point of intersection draw a line across to the left hand side (y-axis). Read the number on the left side of the chart closest to intersection; this is the Q-value for that particular test result. Record the Q-value in the second column of the Chemical Monitoring Data Sheet. You can also check the Q-value table (as an alternative to reading the graph) if your result is close to a given value.

What does a Q-value mean?

You can think of a Q-value as a "Quality-value." It helps interpret your results in terms of the overall health or water quality of your stream. Think of it like a grade. The higher the Q-value, the better the test results (100 is the maximum value; 0 is the minimum).

** EXAMPLE **

Chemical Monitoring Work Sheet

Date	5-26-04
Time	1:00pm
Stream Name and Site ID	White River Site 0001
Air Temp	29.5 °C
Water Temp	22 °C
Lat	°N
Long	°W

Current Weather ☐ Clear/Sunny ☒ Overcast ☐ Showers ☐ Rain (Steady) ☐ Storm (Heavy)

Worst Weather in Past 48 hrs ☐ Clear/Sunny ☐ Overcast ☒ Showers ☐ Rain (Steady) ☐ Storm (Heavy)

	Units	Sample 1	Sample 2	Sample 3	Average
Dissolved Oxygen (DO)	% Saturation				85%
	mg/L	8.0	7.0		7.5
Avg DO (original)	mg/L	7.5	7.5	7.5	7.5
— DO after 5 days	mg/L	— 6.0	— 5.0	— 5.5	— 5.5
BOD 5-day (difference)	mg/L	1.5	2.5	2.0	2.0
E. Coli Bacteria *(purple/blue-violet colonies)*	colonies/ 100 mL	215	185		200
General Coliforms *(pink/magenta colonies)*	colonies/ 100 mL	440	320		380
pH	units	8.0			8.0
Temp at Your Site	°C	22	22	22	22
— Upstream (1 mi) Temp	°C	— 22	— 21	— 21	— 21.33
Temperature Change	°C	0	1	1	0.67
Orthophosphate	mg/L	0.6			0.6
Total Phosphate *(add acid and boil for 30 min)*	mg/L	0.06			0.06
Nitrate (NO_3) *(after multiply by 4.4)*	mg/L	10.0			10.0
Nitrite (NO_2) *(after multiply by 3.3)*	mg/L	0			0
Transparency *(from Tube)*	cm	25	26	27.5	
Turbidity *(from chart – use in database entry)*	NTU	30	29	25	28
Ammonia Nitrogen	mg/L				
Other _______________					
Other _______________					
Other _______________					
Other _______________					

Chemical Monitoring Work Sheet

Date	
Time	
Stream Name and Site ID	
Air Temp	°C
Water Temp	°C
Lat	°N
Long	°W

Current Weather ☐Clear/Sunny ☐Overcast ☐Showers ☐Rain (Steady) ☐Storm (Heavy)

Worst Weather in Past 48 hrs ☐Clear/Sunny ☐Overcast ☐Showers ☐Rain (Steady) ☐Storm (Heavy)

	Units	Sample 1	Sample 2	Sample 3	Average
Dissolved Oxygen (DO)	% Saturation				
	mg/L				
Avg DO (original) − **DO after 5 days** = **BOD 5-day (difference)**	mg/L				
***E*. Coli Bacteria** *(purple/blue-violet colonies)*	colonies/ 100 mL				
General Coliforms *(pink/magenta colonies)*	colonies/ 100 mL				
pH	units				
Temp at Your Site − **Upstream (1 mi) Temp** = **Temperature Change**	°C				
Orthophosphate	mg/L				
Total Phosphate *(add acid and boil for 30 min)*	mg/L				
Nitrate (NO_3) *(after multiply by 4.4)*	mg/L				
Nitrite (NO_2) *(after multiply by 3.3)*	mg/L				
Transparency *(from Tube)*	cm				
Turbidity *(from chart – use in database entry)*	NTU				
Ammonia Nitrogen	mg/L				
Other _______________					
Other _______________					
Other _______________					
Other _______________					

Chemical Monitoring Data Sheet
(Water Quality Index) Instructions

As you complete each chemical test (or average your results from the Chemical Monitoring Work Sheet), record the values in the first column of the chemical monitoring data sheet.

Test Results

	7.5	mg/L
Dissolved Oxygen	85	% saturation
E. coli	200	colonies/100ml
pH	8.0	units
B.O.D. 5	2.0	mg/L
H_2O Temp Change	0.67	change in°C
Total Phosphate	0.06	mg/L
Nitrate (NO_3)	10.0	mg/L
Turbidity	28	NTU's

Use the Q-charts or Q-tables in this chapter to derive the Q-values for each test. Record them in the second column.

	Test Results		*Q-Value*
	7.5	mg/L	
Dissolved Oxygen	85	% saturation	92
E. coli	200	colonies/100ml	37
pH	8.0	units	82
B.O.D. 5	2.0	mg/L	80
H_2O Temp Change	0.67	change in°C	90
Total Phosphate	0.06	mg/L	98
Nitrate (NO_3)	10.0	mg/L	51
Turbidity	28	NTU's	53

After the Q-values have been determined and recorded in the second column, multiply the Q-value for each test by the Weighting Factor and record the value in the final Calculation column.

Test Results			*Q-Value*		*Weighting Factor*		*Calculation*
	7.5	mg/L					
Dissolved Oxygen	85	% saturation	92	X	.18	=	16.56
***E.* coli**	200	colonies/100ml	37	X	.17	=	6.29
pH	8.0	units	82	X	.12	=	9.84
B.O.D. 5	2.0	mg/L	80	X	.12	=	9.6
H_2O Temp Change	0.67	change in°C	90	X	.11	=	9.9
Total Phosphate	0.06	mg/L	98	X	.11	=	10.78
Nitrate (NO_3)	10.0	mg/L	51	X	.10	=	5.1
Turbidity	28	NTU's	53	X	.09	=	4.77

Once the calculations are completed for each parameter, you can then sum the Weighting Factor column and the Calculation column. Divide the total of the *Calculation* column by the total of the *Weighting Factor* column to obtain the Water Quality Index (WQI).

TOTALS 1.0 72.84

Excellent	90 - 100%	Bad	25 - 50%
Good	70 - 90%	Very Bad	0 - 25%
Medium	50 - 70%		

WATER QUALITY INDEX RATING **Good!**

If you complete all eight tests, the total of the Weighting Factor column is 1.00 (or 100%). If you are missing one or two tests (but no more than two!) you can calculate an adjusted Water Quality Index (WQI) Rating. Follow the same procedures: Divide the total of the *Calculation* column by the total of the *Weighting Factor* column for the tests you completed to obtain the adjusted WQI.

In the above example, if the Total Phosphate and *E.* coli tests were not completed, the total of the *Weighting Factor* column would be **0.72**, and the total of the *Calculation* column would be **55.77**

Total of Calculation column (Divided by) Total of Weighting Factor column = Adjusted Water Quality Index Rating

55.77 / 0.72 = 77.46 Good !

CHEMICAL MONITORING DATA SHEET

Date ____/____/____ MM DD YY

Begin Time _____:_____ (am/pm) # Adults __________________

End Time _____:_____ (am/pm) # Students __________________

Certified Monitors' Names____________________________________ Volunteer ID_______________

Organization Name ____

Watershed Name _______________________________________ Watershed # __ __ __ __ __ __ __ __

Stream/River Name ____ Site ID __________________

(Please do not abbreviate.) (Above ID numbers are required.)

Current Weather ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (Steady) ☐ Storm (Heavy)

Weather in Past 48 hrs. ☐ Clear/Sunny ☐ Overcast ☐ Showers ☐ Rain (Steady) ☐ Storm (Heavy)

WATER QUALITY INDEX (WQI)

You may perform as many of the following tests as you wish; however, at least 6 must be completed to obtain a Total Water Quality Index value. Divide the total of the *Calculation* column by the total of the *Weighting Factor* column to obtain the Water Quality Index rating.

Test Results			*Q-Value*		*Weighting Factor*		*Calculation*
	________	mg/L					
Dissolved Oxygen	________	% saturation	_____	X	.18	=	_______
***E.* coli**	________	colonies/100mL	_____	X	.17	=	_______
pH	________	units	_____	X	.12	=	_______
B.O.D. 5	________	mg/L	_____	X	.12	=	_______
H_2O Temp Change	________	change in°C	_____	X	.11	=	_______
Total Phosphate	________	mg/L	_____	X	.11	=	_______
Nitrate (NO_3)	________	mg/L	_____	X	.10	=	_______
Turbidity	________	NTU's	_____	X	.09	=	_______
			TOTALS		_______		_______

Excellent	90 - 100%	Bad	25 - 49%
Good	70 - 89%	Very Bad	0 - 24%
Medium	50 - 69%		

WATER QUALITY INDEX RATING ☐